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# RAPIDS - A PC-based local ground station

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**ABSTRACT**
The lack of direct access to satellite data is a major global restriction on resource management needs in developing counties. The removal of this obstacle lies in direct readout satellite transmissions and low cost, reception systems for local area data acquisition and processing. This paper outlines RAPIDS (Real-time Acquisition and Processing - Integrated Data System): a local low cost PC-based ground station for the acquistion and processing of high resolution SAR data and optical data from the ERS satellites, the SPOT satellites and the J-ERS satellite. In addition to the description of RAPIDS, two major projects will be outlined which will demonstrate the use of RAPIDS for resouce management in an operational environment.

## Abstract

The lack of direct access to satellite data is a major global restriction on resource management needs in developing countries. The removal of this obstacle lies in direct readout satellite transmissions and low cost, reception systems for local area data acquisition and processing. This paper outlines RAPIDS (Real-time Acquisition and Processing – Integrated Data System): a local low cost PC-based ground station for the acquisition and processing of high resolution SAR data and optical data from the ERS satellites, the SPOT satellites and the J-ERS satellite.
In addition to the description of RAPIDS, two major projects will be outlined which will demonstrate the use of RAPIDS for resource management in an operational environment.

## Contents



(26 pages in total)

## Introduction

There is a clear environmental and commercial need to stimulate high resolution data markets and product uptake in both developed and developing world. An EU funded study [1] on the constraints and opportunities of Earth Observation in developing countries identified the lack of more direct access to satellite data as a major global restriction on resource management needs in these countries.

Reduced ground station operational costs, lower data (capital and running) costs, together with an improved, timely service to customers, especially in developing countries, will remove this obstacle and will be highly advantageous for applications development and market growth. So much so, that access to remote sensing data will become increasingly open to many potential users that would otherwise not be aware of, or inclined to utilise earth observation products and information.

Remote sensing satellite operators and data providers currently rely on a system of large, regional ground stations for operational data acquisition and dissemination. However, this presents significant obstacles to meeting the needs for inexpensive and timely data of a very large number of potential EO users. Most of the investment in Earth Observation (EO) goes into the space segment rather than the ground segment. What the user sees of EO is the data distribution (ground segment) side. Growth in demand, the variety of satellite data available and increases in the number of applications mean that greater flexibility in data access is therefore necessary to improve the supply side. This requires increased consideration of direct broadcast and a lower level of control on data distribution [2].

## Problems in the access to data

In many previous studies problems have been observed in the access to data, especially but not limited to developing countries [1, 3, 4].
Access to data, especially when data are crossing borders, is hindered by technical factors, by economic factors and by political factors.
Technical factors relate to:
- Cloud problems [Optical satellites cannot see through the clouds]
- Interpretation of SAR data is perceived as being difficult
- Training and education are lacking

Economic factors relate to:
- Prices of data are too high
- Ground station access fees are too high
- Copyright

Political/Institutional factors relate to:
- Security issues
- National prestige
- Autonomy

The political and institutional factors can cause the most problems, particularly in developing countries. Especially with regard to regional operating ground stations, it is virtually impossible to obtain data from these stations unless you are a user in the same country. The CRISP ground station in Singapore is a notable exception and perhaps the only positive example in this respect.

## The example of RAPIDS

Research developments funded by the UK Government Department For International Development (DFID) and British National Space Centre (BNSC) have produced RAPIDS - a PC based receiver system for ERS, SPOT and J-ERS data. In parallel, The Netherlands Remote Sensing Board (BCRS), the Netherlands Agency for Aerospace Programmes (NIVR) and NLR are funding the development of the data processing system and are funding a number of field trials in Europe and overseas [5].

### RAPIDS design requirements

The Real-time Acquisition and Processing - Integrated Data System (RAPIDS) is a PC-based X-band receiver designed to provide local users with rapid access to earth observation data at least cost.

The design philosophy of the RAPIDS PC-based transportable ground station is to meet national and/or local needs for timely environmental data. In most countries, a large number of resource managers, planners and decision makers would benefit from timely information on their environment, if it were available promptly (on demand), reliably and as inexpensively as possible [6]. For these local areas/users the demands are less than for horizon-to-horizon systems. Thus the resulting ground segment can be inexpensive, easy to transport, install and maintain.

The principal design requirement is for a system to handle capture for local areas when the satellite is within $\pm$ 45° of the overhead position. The system has to maximise control during these passes where the rate of change in satellite position is highest. The $\pm$ 45° cone of acquisition enables capture of small unit volumes of data of local interest. The system also has to be robust enough to minimise the effect of wind forces during tracking, and to be simple to maintain and operate. Standard PCs were selected as the platforms for management, tracking, capturing and processing of data. This is because of their increasing performance/cost advantage and their widespread availability and use (compared to UNIX workstations) in developing countries. This makes for easier local maintenance and cost-effective integration with existing capacity BURS designed and now manufacture the system. NRI and NLR provide processing software, applications development, project implementation and technical support.

### RAPIDS satellite tracking and data reception

Many high resolution satellites include a beacon (e.g. ERS) or data signal operating on a 2.2 GHertz signal, the satellite pointed tracking is done using this frequency. All the current high resolution satellites transmit data on the 8 GHertz band and these data streams are collected separately so as not to mix the tracking function with data collection issues.

The current set-up for receiving consists of a dish antenna of 2.7 metres that can be tilted over a range of +60° to -30° in two perpendicular directions. This range is enough to capture data within a circular area of approximately 1000 km diameter, depending on the site. A set of four patch aerials each with its own low noise amplifier for the 2.2 GHz tracking system is mounted at the dish centre. The 8 GHz data reception LNA is positioned in the same focal plane as the patch aerials at the centre of the dish.

The antenna dish is moved by a hydraulic configuration. A hydraulic power unit with oil reservoir pumps, motors, and valves controlling the drive rams is used to move the aerial. Position monitors are linked to the power supply for safety cut out, "safe park" mode and alarms. The receiver system is thus capable of tracking on S-band beacon signals and capturing X-band data signals from satellites over 90 arc-degrees using a 2.7 metre antenna. Capability currently includes ERS, SPOT and JERS. Potentially, other satellites (e.g. IRS, Landsat, EOS et al) could be added to the capability.

Data rates that can be captured vary from 6 Mbits sec$^{-1}$ to 150 Mbits sec$^{-1}$. For example, the data rate of ERS is 105 Mbits sec$^{-1}$. These data rates limit the use of standard computers. Nonetheless, due to improvements in computer technology it is possible to capture these data using fast hard disks and by addressing large volumes of electronic RAM in the capture PC. At present, the size of each volume of data capture has been determined at 512 Mbytes (approximately 38 seconds of ERS data transmission).

**RAPIDS system**

RAPIDS consists of four major subsystems:

- Tracking of SPOT, ERS and JERS satellites
- Data capture for SPOT, ERS SAR, JERS Optical and JERS SAR
- Frame and data synchronisation
- QSAR processor and QOPT processor

The subsystems are currently configured in such a way that separate PCs are utilised for specific functions.

**RAPIDS data acquisition**

The orbit planning for ERS, SPOT and JERS takes place on one PC. This is used to send timing information to both the tracking and data receiver control/monitor computers. These computers in turn control and monitor the whole tracking and reception process and return signals via RS232 links for logging of the system operation. The computers also link to various power supplies for control and monitoring and various warning and safety devices.

Figure 2 shows the orbit planning user interface. The ground track is indicated in red, the window opposite the map gives the satellite details. Input to the orbit planning is based on standard TLE (Two Line Element) data, which are available via the Internet.

A second, Pentium based PC is used to set up the tracking receiver, to process the patch aerial signals and to generate signals to drive the aerial. The tracking receiver is a dedicated processor system to lock onto beacon signals and provide patch signal information.

A third Pentium based PC is used to set up, control and monitor the data receiver and data demodulator. The data receiver is a general purpose programmable X-band receiver, operating

in the range 8 to 8.4 GHz. There is set of data demodulators for each channel of each satellite. Data capture for specified parts of an orbit takes place on this third PC. Currently the capture capacity of a standard system is selective capture of 0.5 Gbytes of data per orbit per computer. In this way it is possible to run a fourth PC (in parallel) to increase data volumes captured to 1 Gbyte.
Frame and data synchronisation, SAR and optical data processing (QSAR for SAR data processing and QOPT for SPOT/OPS data processing) and the generation of output products takes place on a further Pentium PC. The PC's are connected to each other by fast Ethernet or RS232 links.

**RAPIDS data processing**
A RAPIDS User Interface (figure 3) has been developed to enable the user to process the data in an easy manner. Three steps can be distinguished:
1. Processing of SPOT/OPS data using QOPT.
2. Frame- and line synchronisation and conversion of raw ERS data into the CEOS-SAR format.
3. Processing of the converted SAR data using QSAR.

**QSAR**
QSAR is a simple SAR processor to process raw SAR data into quick-look images of the captured data. The design philosophy is based on the assumption that users want a simple, easy-to-handle, easy-to-understand software tool enabling them to transform raw radar data into an image to assess the information content. As standard Pentium PC platform was selected, operating under Windows'95 or Windows NT. Because of the need for local PC serviceability, local acceptance and of local integration, software running on PC's is a prerequisite for running an operational service, particularly in developing countries.
The number of QSAR output products is selectable (see figure 4). The default parameters only process data in a 64m pixel spacing Windows bitmap (see figure5; options 16m and 23m), for which it is not necessary to have (expensive) image processing software (MS-Paint can read it!). Alternative options are to process the data into 32 bits intensity and/or phase data. These options are normally used in a more scientific environment.
On the basis of the intensity and phase information, contained in the data, it is possible to develop dedicated SAR processors. These dedicated processors take into account the basic ERS data but are constructed in such a way that they process the data into information, taking away the burden for the user. Currently, dedicated QSAR processors exist for determining the extent of flooded areas in rice areas (FLOODSAR: a collaboration between Synoptics, NLR and EGIS) and for determining the bathymetric information in ERS data (BASSAR: a collaboration between ARGOSS and NLR).

**QOPT**

In developing QOPT, the same philosophy was followed as with QSAR. QOPT has been developed in collaboration with Paradise Green Technical Services from the UK. Basic SPOT output products are level 0 data (i.e. raw data; no corrections) and level 1A data (i.e. radiometric corrected data). The latter is performed using the calibration coefficients as provided by SPOTImage.

QOPT basically performs a frame- and line synchronisation and the subsequent processing into level 0 (see figure 6) or level 1A products. Output is presented in Windows bitmap (.bmp) format, which makes it possible to display the output in MS-Paint (included in every Windows-version).

**RAPIDS details**

RAPIDS is now being put on the market by NRI (Contactperson: Ian Downey). A typical price is 500.000 US$. That price includes:

- Trailer, including 2.7 m dish antenna and hydraulics
- Receiver system
- Power supply
- Two capture PC's
- One tracking PC
- One orbit planning PC
- One processing PC
- Two CD writers
- Orbit planning software
- Acquisition diagnostics software
- Tracking software
- Dish handling software
- Capture software
- RAPIDS processing software, including QSAR and QOPT
- Support for one year
- Installation, including shipment.
-

Licence fees for ERS, SPOT and J-ERS are not included. These fees are estimated at:

- ERS: Total fee amounts 400 US$/scene, composed of an access fee of 220 US$/scene and a royalties fee of 180 US$/scene.
- SPOT: The fee depends on whether the user is interested in data per area or data per seonds (minimum 7 seconds). The price per 7 seconds has been estimated at 250 US$.
- JERS: The negotiations with NASDA are on-going.

**Advantages of RAPIDS**

RAPIDS is essential in providing a direct link between the data and the use of that data. The advantages are:

1. Investment costs are less compared to large ground receiving stations.
2. Running costs are less compared to large ground receiving stations.
3. Local area reception reduces the long lead times before data actually gets in the hands of the users.
4. Data needs can be tuned to the actual needs of the user of which it is assumed that the user will be the operator of the ground receiving station.
5. Data access is controlled by the user, the user remains autonomous
6. There is no exchange of foreign currency across borders, required when ordering data at a regional, large ground receiving station. Royalties need to exchanged.

## Experience in the Netherlands

Since November 1997, a RAPIDS system has been installed at NLR Noordoostpolder (see figure 1). During that period the system has been demonstrated to a wide audience of interested organisations. At the same time the system has been used routinely in support of specific operations. The operational experience of the NLR operators indicates that a minimum of operator intervention is required. It takes in general one to two hours to plan, acquire, process and archive optical data and between two and three hours to plan, acquire, process and archive SAR data. Of this time approximately 85% is processing time.
Transportation of the system to a different location has been demonstrated. In May 1998 the system was succesfully transported and installed at ITC in Enschede during the annual EARSeL symposium [7].
The coverage of the ground station is indicated in figure 7.
In close collaboration with the Netherlands SPOT data distributor, Geoserve bv, several SPOT data were successfully captured, processed and put on the Geoserve website.
From October/November this year the RAPIDS ground station will be used to monitor early crop estimates based on the ERS radar data and will be used to monitor crop estimates throughout the 1999 growing season using SPOT and ERS data. The crop estimates will be estimated by Synoptics bv in support of the Netherlands agri-business.

## Experience in Bangladesh

In the framework of the ESA Data User Programme, a project proposal was submitted by Synoptics BV, NLR and EGIS to set up a RAPIDS system in Bangladesh to set up a RAPIDS system in Bangladesh under the Water Resources Planning Organisation (WARPO) under the Ministry of Water Resources. The project is part of a long-term programme to deliver timely information on floods in Bangladesh. NRI and BURS are supporting the project through technical and applications support for operations in Bangladesh.

During the monsoon season of 1999, a RAPIDS system will be stationed in Dhaka, Bangladesh at the Environment and Geographic Information Systems Support for Water Sector Planning (EGIS), to perform flood monitoring and mapping. This will be performed under ESA contract, as part of the Data User Programme.

NLR, NRI and BURS will install the RAPIDS system in Bangladesh. NLR will train EGIS operators in the use of RAPIDS and use of the dedicated SAR and optical processing software and, together with NRI and BURS, will support operation throughout the monsoon season.

Synoptics BV, a Dutch value-adding company will install dedicated software, running under ERDAS, to analyse the data for flood monitoring and flood mapping.

EGIS is responsible for offering an operational service in running the RAPIDS system and in providing flood mapping and monitoring products to various users in Bangladesh, allowing instant views of flooding and other environmental characteristics with applications in flood modeling and forecasting, coastal and river morphology, crop monitoring, etc.

RAPIDS will make it more possible to develop a near-real-time flood mapping and monitoring capacity on Bangladesh. In addition there is potential for a number of other applications which could involve co-operating agencies in Bangladesh, such as WARPO, Flood Forecasting and Warning Centre of the BWDB, SWMC, SPARRSO, Meghna Estuary Study, etc.

Currently the methodology for retrieving the flood information is being developed. Based on historical data, available from Bangladesh (see figure 8) and data acquired during the 1998 monsoon season, the dedicated FLOODSAR processor will be developed. This processor will then be tested during the monsoon season of 1999 in an operational environment.

## Experience in Indonesia

A field trial is also planned in Indonesia. During October/November this year, a RAPIDS station will be installed, demonstrated and operated near Jakarta, Indonesia. The objective of the demonstrations is to improve the appreciation of the usefulness of near real time data delivery in support of real management decisions. In particular the data will be used to:

- Assess forest areas in Southern Sumatra (with respect to forest fire damage and deforestation) in support of the EU Forest Sector Support Programme and the Netherlands Tropenbos/ Ministry of Forestry research project.
- Determine the bathymetry in Banka Strait in support of the joint Indonesian/Netherlands SIMBA project.
- Assess the coastal zone in Banten bay in support of the Royal Netherlands Academy of Sciences Global Change project and in support of the Aerospace Programme on Education, Research and Training Programme (APERT).
- Assess the usefulness of the RAPIDS data for rapid estimates of rice extent and production estimates in support of the SARI (Satellite Application for Rice in Indonesia).

During a 6 weeks period, RAPIDS will be used to fulfil the data needs of the above projects. RAPIDS will be installed at two different locations near Jakarta.

## Discussion

A great many applications using high resolution optical and SAR data have already been developed to support environmental monitoring and decision making around the world. Easier access to less expensive high resolution data would lead to an explosive growth in its utilisation by developing countries.

However, institutional issues need very careful consideration. Significant previous experience with direct reception of (low resolution meteorological) satellite data and its implementation in-country has been obtained. This experience shows that remote sensing applications, which improve already on-going activities, are more likely to start well, and be sustained, than applications in totally new domains. Once potential customers get used to seeing such products on a regular basis, ideas and interests develop to diversify the use of the data for other purposes. It is anticipated that this will be the case in Bangladesh and Indonesia.

This process has to start with the real decision making needs of the many potential users and customers. Focussing remote sensing onto operational activities and needs helps to avoid institutional inertia that may arise with (for example) a self-serving, highly centralised remote sensing centre. It is also important to prepare the Institution for the associated, and necessary, changes in working practice and attitude towards information use and provision. Once started, sustained operation of a satellite receiver and associated data processing routines requires a commitment to (minimal) running costs as an essential prerequisite [6].

Operational remote sensing in developing countries can thus be sustainable if applications, benefits and costs are carefully matched by the means of appropriate technology.

## Conclusions

RAPIDS is now available on the market. It is a good example of how appropriate technology can be used to make meaningful contributions in a developing country. From the experience gained sofar in the Netherlands and judging from the positive reactions that have been received, RAPIDS clearly shows promising features to stimulate the uptake of remote sensing applications. One aspect that has become evident is that users realise through RAPIDS that it is possible to get vast amounts of data in a regular and cost-effective manner. The conditions that govern access, distribution and pricing of EO data are vital to the exploitation of this important environmental information resource [2].

The lack of more direct access to satellite data is clearly a major global restriction on resource management needs in developing countries. The removal of this obstacle lies increasingly in direct readout satellite transmissions and the capabilities of low-cost, reception systems for local area data acquisition and processing.

Results to date demonstrate that the capabilities of low cost, PC based date reception and processing can be realised. The innovative RAPIDS system is optimally suited to regular reception of moderate amounts of data, to meet the real-time needs of customers and users within a radius of the order of 1000 km.

Together, BURS, NRI and NLR are working closely to actively promote and develop RAPIDS. This is to enable a growing number of institutes and organisations in developing countries (and elsewhere) to access and utilise this technology for improved understanding and management of their natural resources.

The potential benefits offer significant advantages for the reception, analysis and distribution of information from the predicted expansion in satellite and sensor availability. Such developments have profound implications for future EO system design, operation, market development and data policy.

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5. http://www.synoptics.nl/ - information about Synoptics
6. http://bppt.go.id/ - information about BPPT
7. http://styx.esrin.esa.it:8099/ - information about ESA's Data User Programme

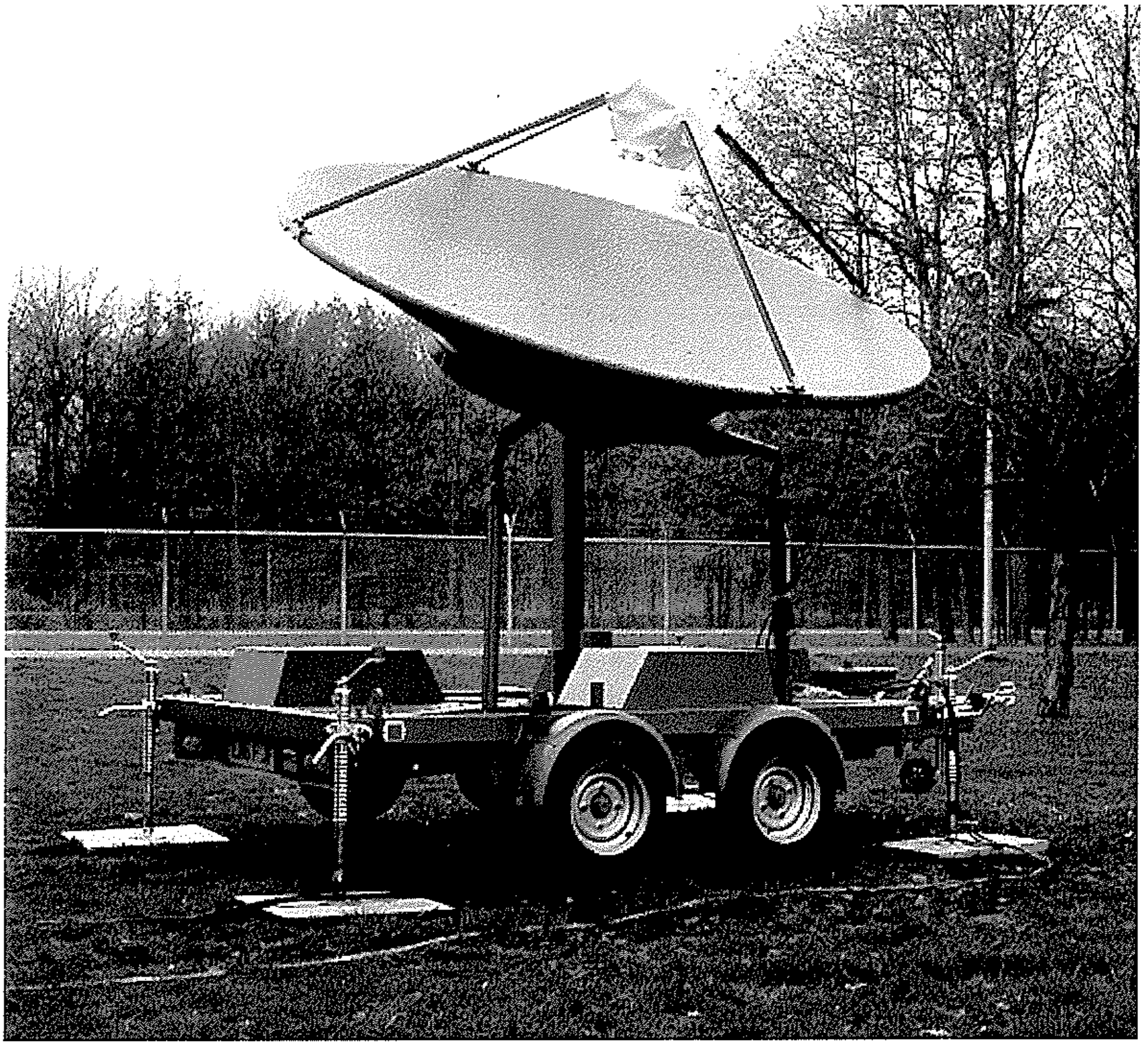

*Fig. 1 RAPIDS system, currently deployed at NLR, Noordoostpolder, The Netherlands*

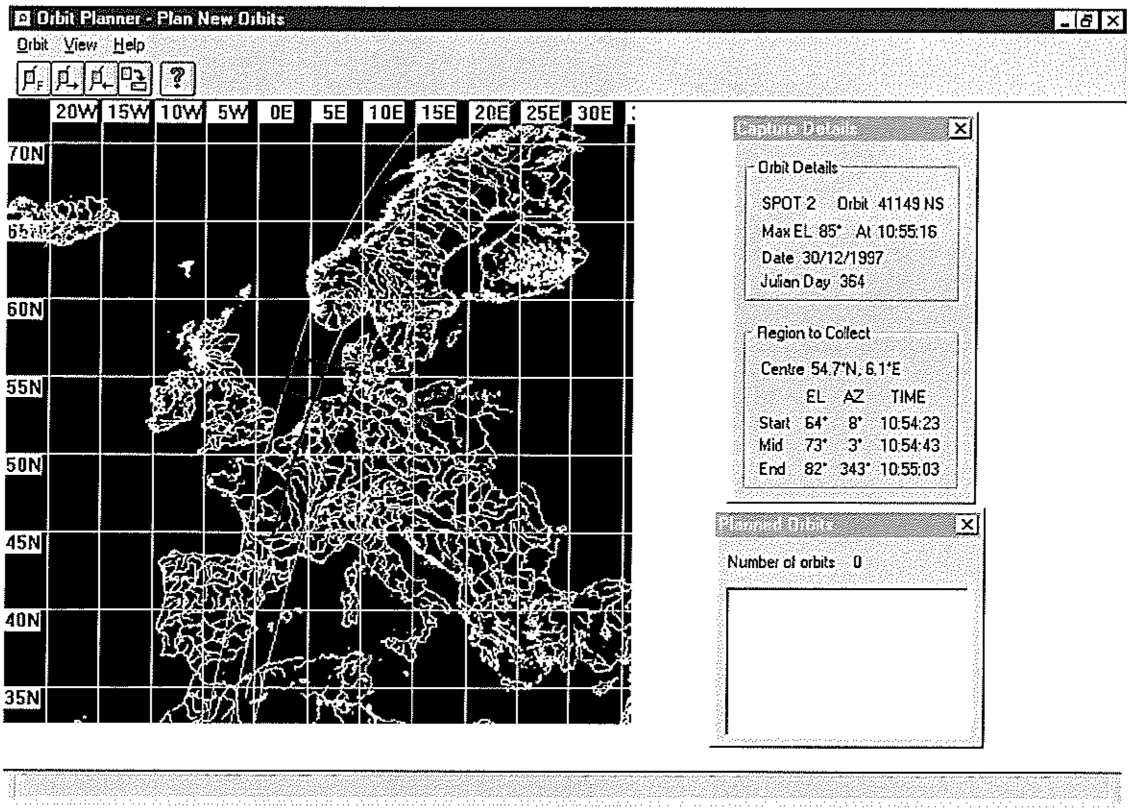


*Fig. 2 Orbit planner User Interface*

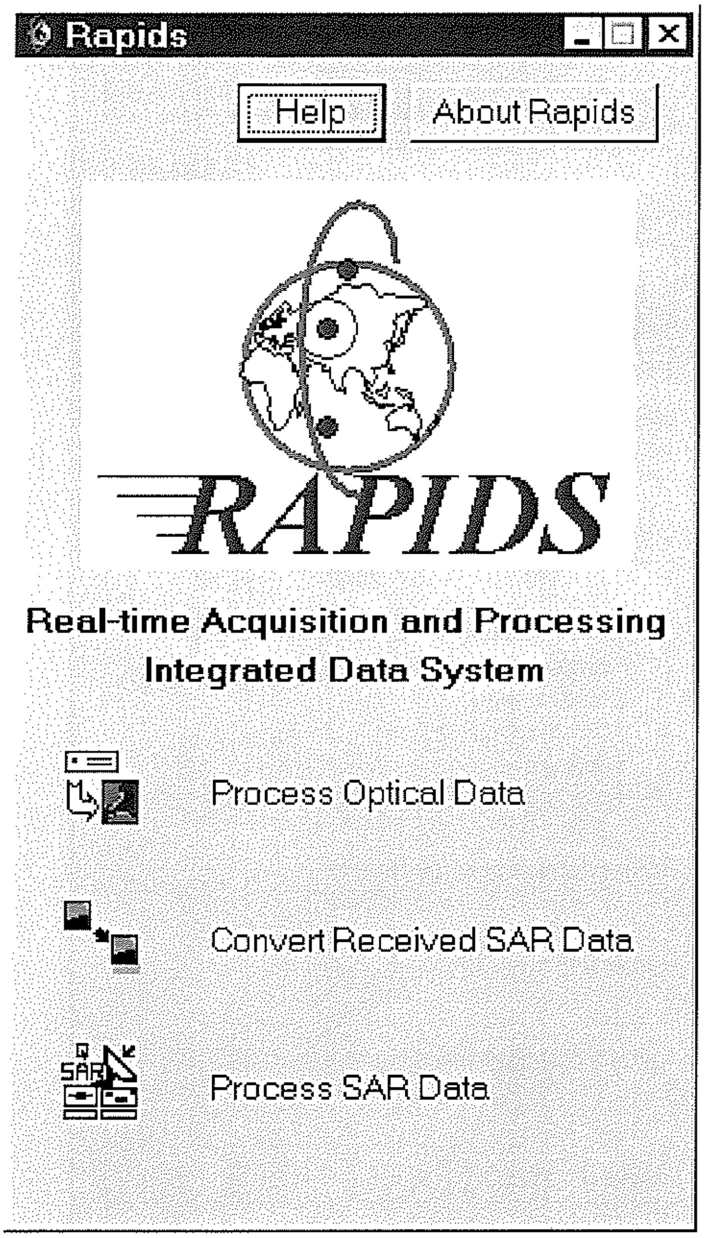


*Fig. 3 RAPIDS User Interface*

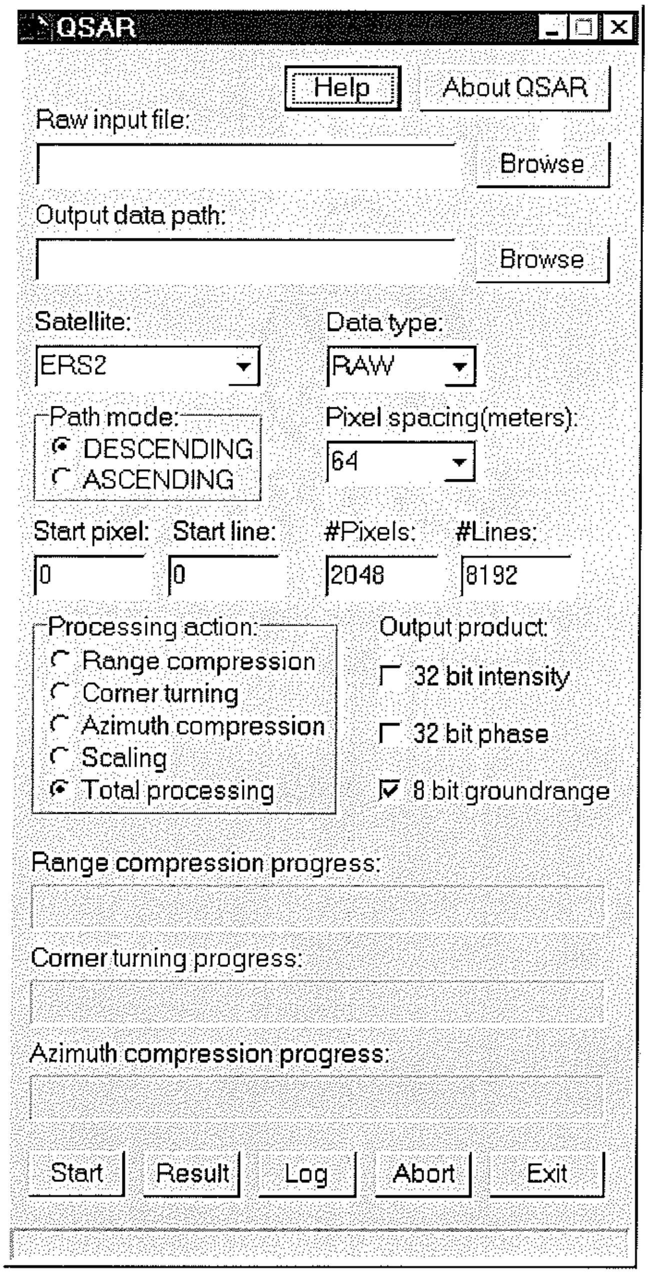


*Fig. 4 QSAR Interface for the Windows NT version*

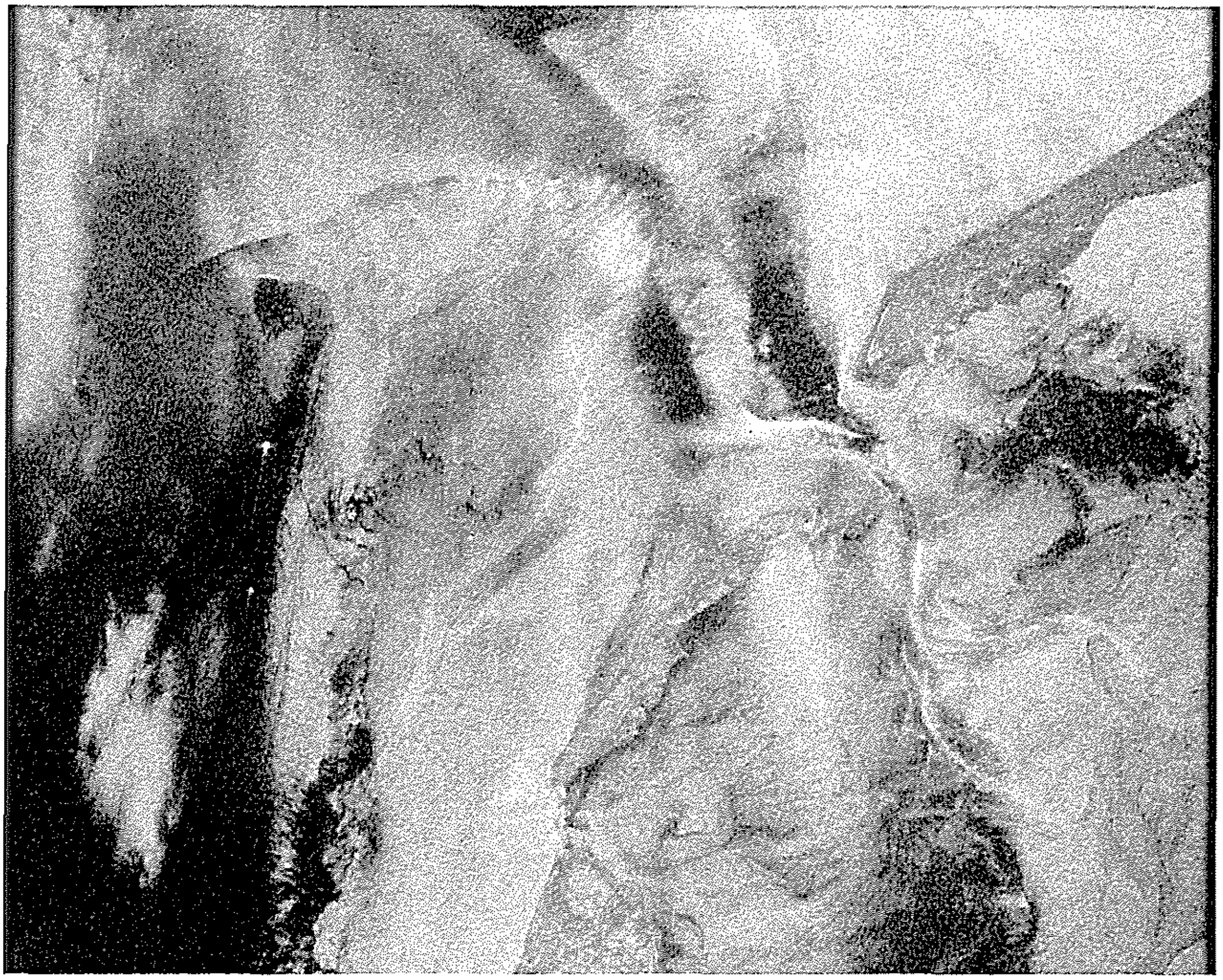

*Fig. 5 QSAR processed 64-m-pixel-spacing image of the Wadden islands Texel and Vlieland Data acquired on 27 th of July 1998 by NLR RAPIDS. Copyright ESA 1998*

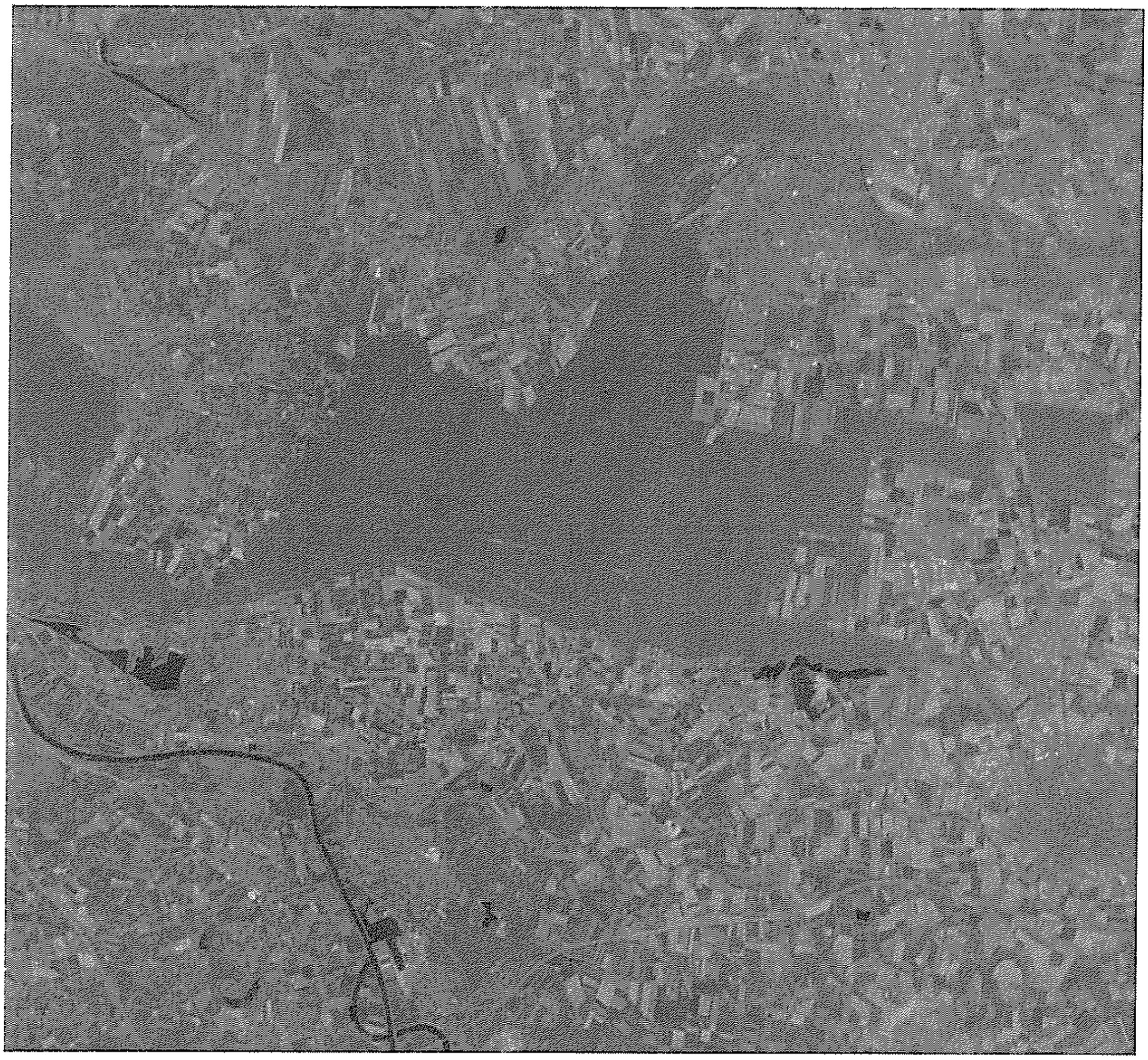

*Fig. 6 QOPT processed 20m resolution image of the Reichswald on the German/Dutch border Data acquired on 8th of August 1998. Copyright CNES 1998*

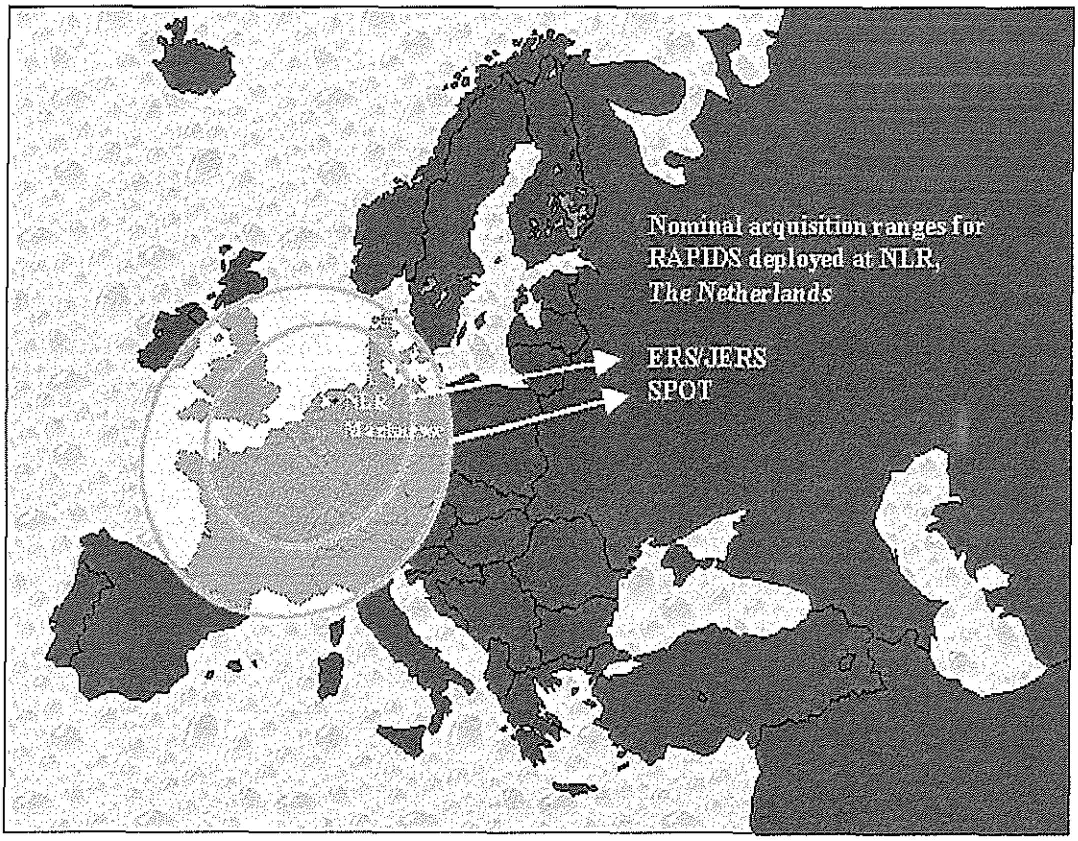


*Fig. 7 Coverage of the NLR RAPIDS station. Note: the satellite coverages are shown here, the actual site coverage is different because of SPOT's ability to look 27 degrees to either West and East direction and because of ERS's ability to look 21 degrees to the West*

*Fig. 8 ERS SAR image, processed by QSAR, acquired on April 1996. The image shows the Jamuna river (North-South direction) and the braiding pattern of the main rivers in Bangladesh Copyright ESA 1996*